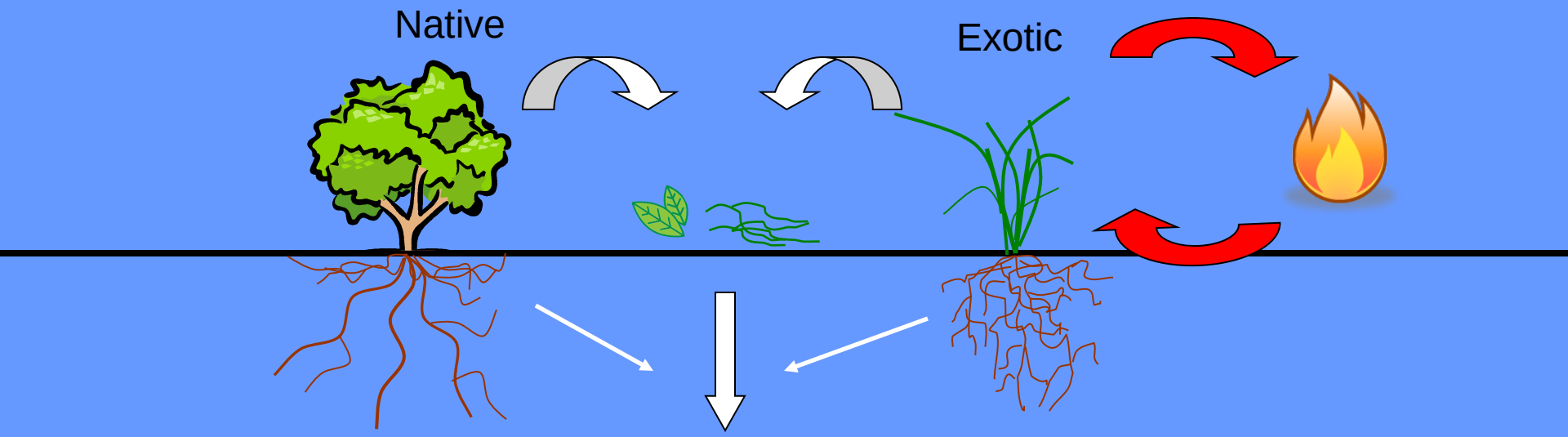
Exotic plant invasion: interrupting chaparral ecosystem resistance, resilience and succession

S.J.M. Dickens*, E.B. Allen,
L.S. Santiago, and D. Crowley

University of California Riverside,

The effect of an exotic on an ecosystem depends on how different it is from natives.

(Ehrenfeld 2003)



- Loss of habitat and diversity
- Increased fire frequency
- Type conversion

- Altered soil chemistry and nutrient cycling
- Altered soil microbial community

Modified from Wolfe and Klironomos 2005 Bioscience

Resistance and Resilience

- Resistance:

  A systems ability to withstand alteration.
  - Structure: plant spp composition, microbial biomass, nutrient content
  - Function: hydrology, nutrient cycling

Bromus rubens

- Resilience:

  A system's capacity for recovery of structure and function following disturbance (Westman 1978; Pimm 1984).

Avena fatua

Eriophyllum confertiflorum

Hypotheses

- Presence of exotic plant species changes the biological and chemical characteristics of the soils by altering soil inputs.
- The presence of exotics plant slows succession of above and belowground system structure and function.
- If exotic plants are controlled and native chaparral plant species restored, soil biological and chemical characteristics will return to pre-invaded conditions because native plant inputs will be restored.

Chaparral Ecosystem

Arctostaphylos glandulosa

- Sclerophyllous evergreen shrubs
- Annual and perennials in the interspaces
- Harsh environments, Mediterranean climate.
- Adapted to infrequent fire.

Adenostoma fadciculatum

North Mountain Research Area (Burned Site)

- San Jacinto Mountains
- Esperanza Fire Oct 26, 2006, 40,200 acres in 18 hours.
- Pre-burn uninvaded areas dominated by shrubs, invaded areas by exotic annuals

Santa Rosa Plateau Ecological Reserve (Unburned Site)

- Murrieta, CA.
- Uninvaded areas dominated by chamise and oak while invaded areas by exotic annuals

Data Collection

Invasion Treatments:

Native = undisturbed by human activity, exotic plant species ≤ 20 percent

Invaded ≥ 50 exotic plant species cover

Restoration Treatments:

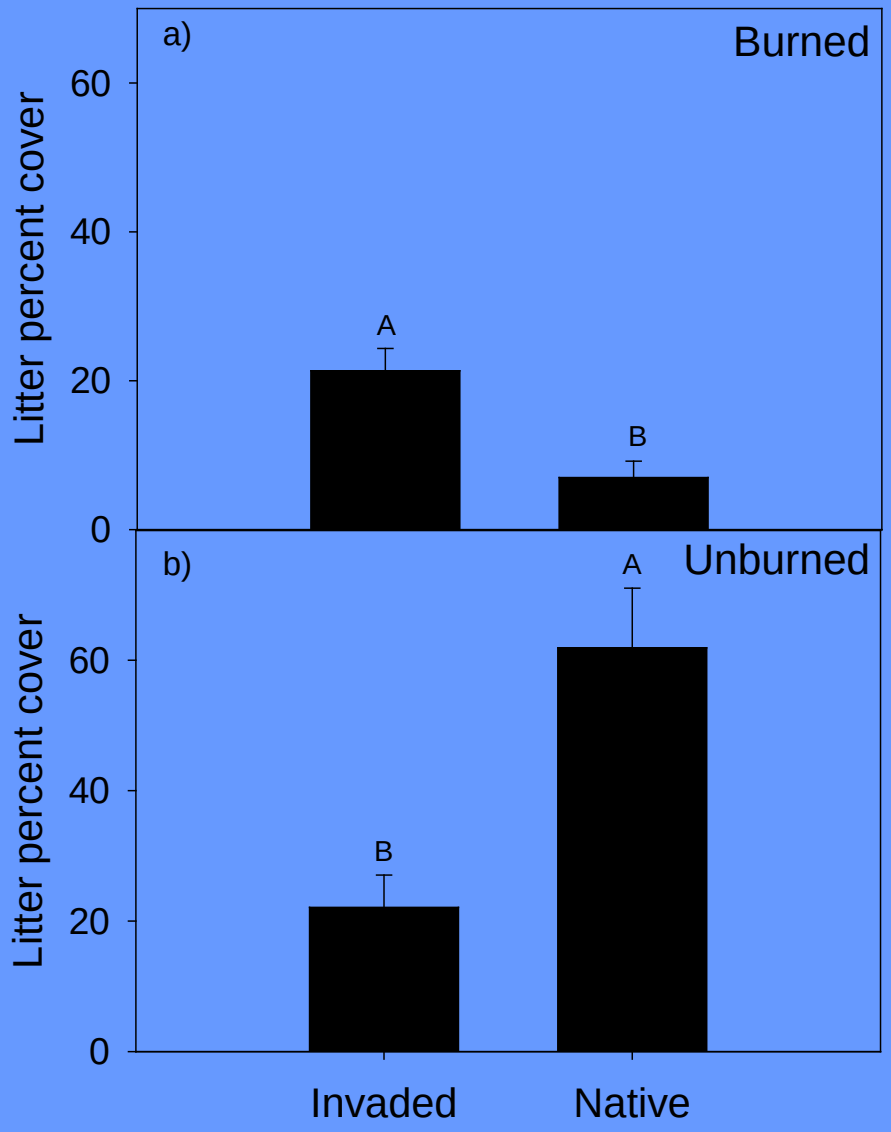
Seeded = Invaded area plus seeding

Weed/seed = Invaded area plus weeding of all exotic plant species and seeding

Ecosystem Variables

- Plant species percent cover and richness
- Soil chemical pools of (C,N,P,OM)
- Phospholipid Fatty Acid Analysis (microbial composition)
- Potential soil respiration
- Potential nitrogen mineralization

Plant Litter Inputs



	C/N
Natives	
Adenostoma fasciculatum	55.9
Arctostaphylos glandulosa	55.9
Exotics	
Avena barbata	62.0
Bromus madritensis ssp. rubens	25.5
Bromus tectorum	30.5
Erodium brachycarpum	67.4
Vulpia myuros	49.7

- Fire and invasion reduced litter percent cover
- Exotic litter percent cover never reached greater than 20% cover
- Invasion altered litter quality.

Soil Chemical Pools

Burned Site

	Invaded	SE	Native	SE	P-value
Pre Fire					
Total N (%)	0.3	<.01	0.2	<.01	0.635
Total C (%)	3.7	0.7	2.9	0.4	0.311
Soil organic matter (%)	2.3	0.2	1.9	0.2	0.314
C/N	14.8	0.5	12.9	0.4	**0.012**
NH4 (ppm)	76.8	17.1	56.0	9	0.572
NO3 (ppm)	7.4	2.1	4.6	0.9	0.235
Total extractable N (ppm)	84.2	55.7	60.6	28.1	0.584
Olsen-P (ppm)	25.6	6.8	19.2	3.1	0.918
pH	5.9	0.1	5.5	0.1	**0.008**
Post Fire					
Total N (%)	0.2	0.1	0.1	0.1	**0.046**
Total C (%)	4.6	0.8	2.1	0.3	**0.012**
C/N	19.0	1.0	17.6	1.9	0.233
pH	5.9	0.1	6.5	0.3	**0.003**

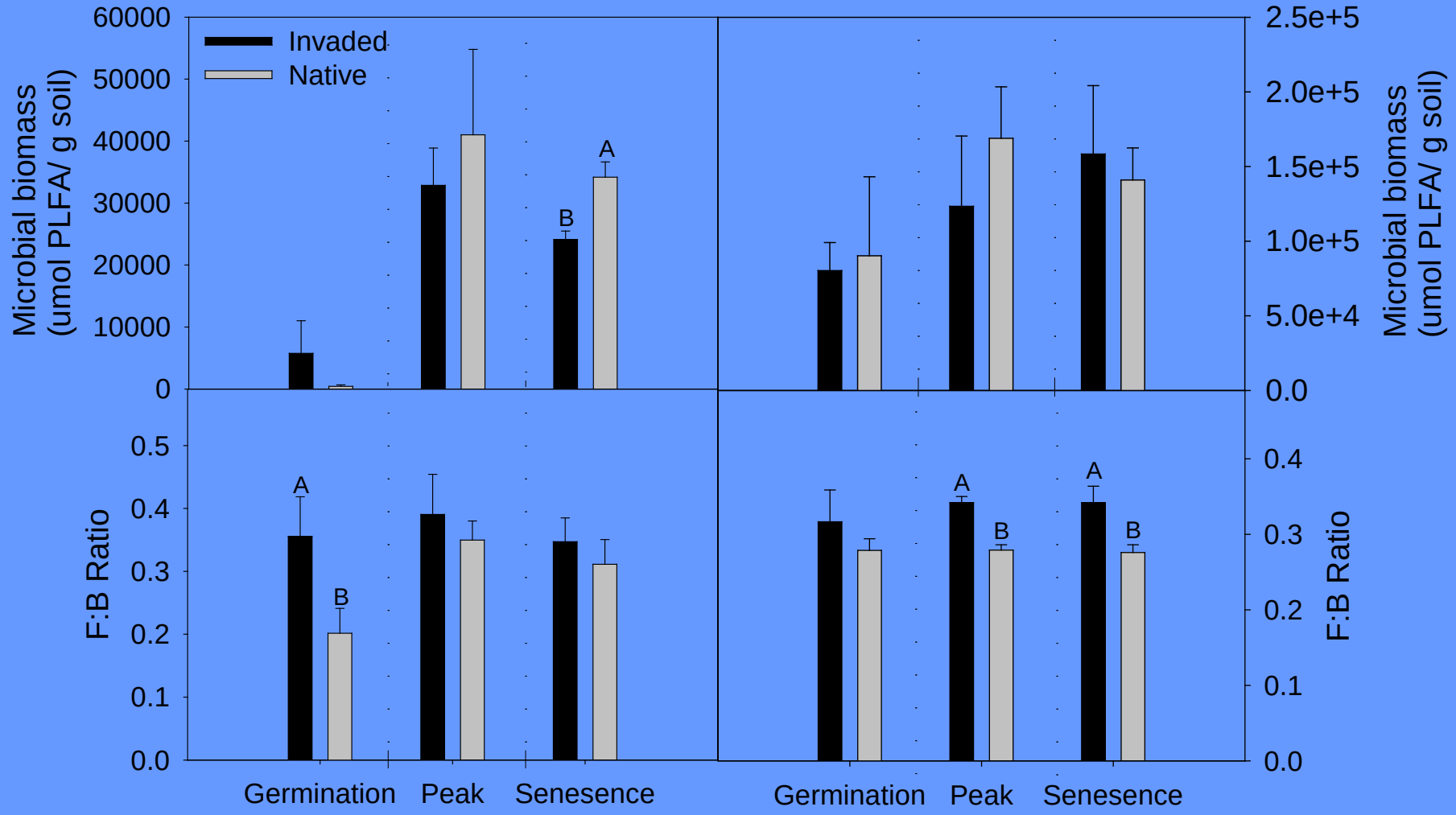
Unburned Site

	Invaded	SE	Native	SE	P-value
Total N (%)	0.2	<0.1	0.3	<0.1	0.204
Total C (%)	2.4	0.3	3.7	0.7	**0.089**
Soil organic matter (%)	5.4	0.6	6.8	0.8	0.192
C/N	13.0	1.4	15.0	1.5	**0.009**
NH4 (ppm)	10.8	1.7	8.7	0.9	0.309
NO3 (ppm)	9.5	1.6	7.5	1.7	0.405
Total extractable N (ppm)	20.3	7.9	16.2	1.9	0.230
Olsen-P (ppm)	4.1	0.9	3.7	0.5	0.730

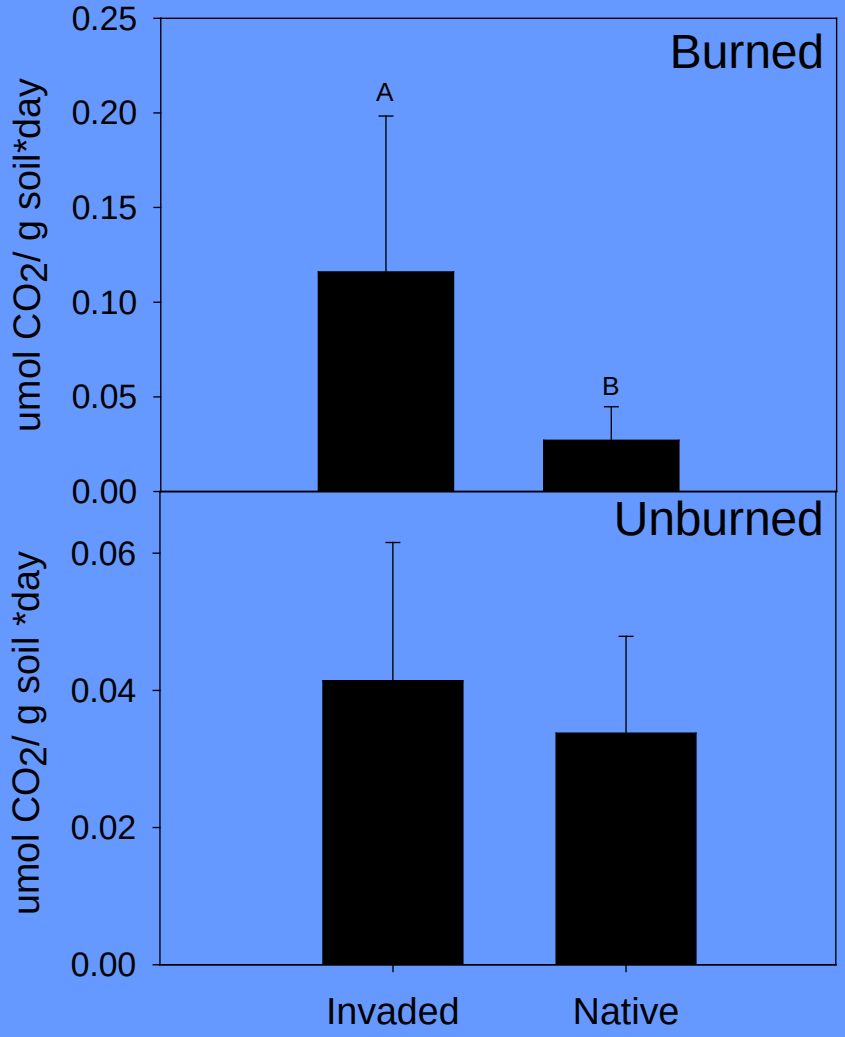
Invasion:

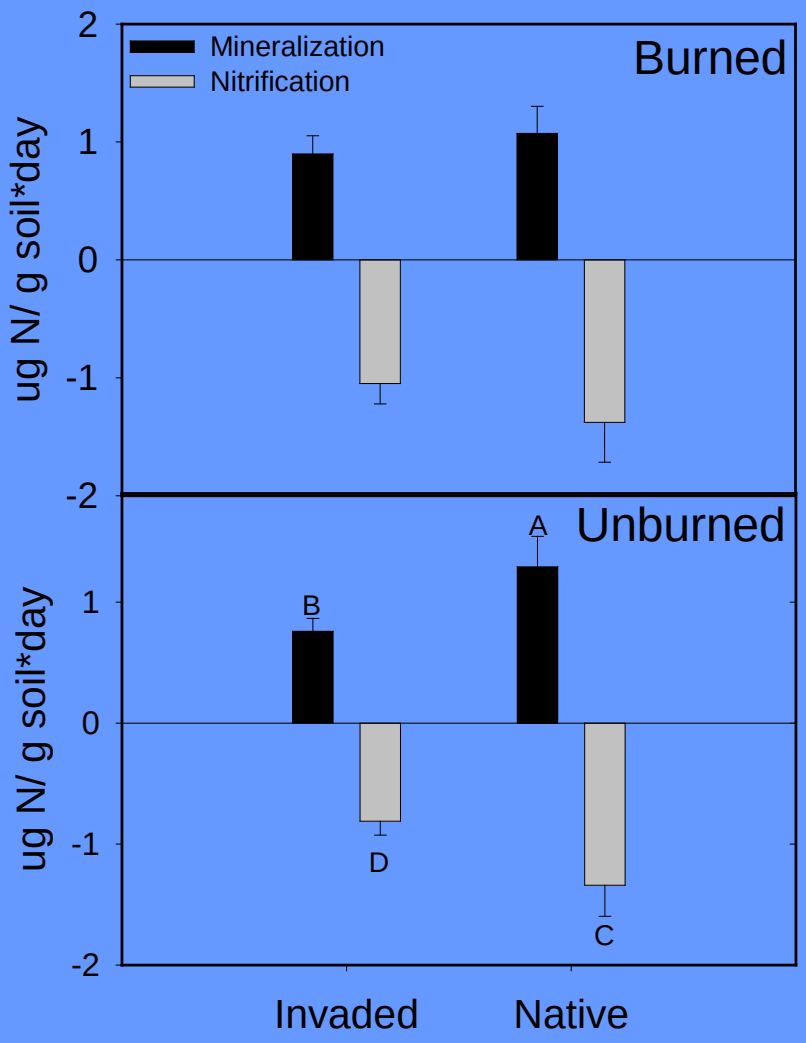
- Increased and decreased soil C/N
- Decreased soil carbon
- Increased soil carbon and C/N of post fire soils

Microbial Community



Carbon and Nitrogen Cycling





Respiration was increased by invasion and nitrogen immobilization was reduced.

Resistance Conclusions

Exotic plant invasion:

- Reduced litter quality and accumulation.
- Altered soil carbon pools
- Decreased fire intensity and altered post fire initial succession conditions.
- Decreased microbial biomass and increased F:B.
- Increased potential soil respiration and reduced nitrogen immobilization.

Experimental Restoration Effects

	Invaded	Seeded	Weed/Seed	Native	P-value
NH4 (ppm)	5.18 (1.9)	3.87 (0.6)	7.78 (1.9)	9.06 (2.5)	0.061
NO3 (ppm)	3.23 (0.7)	4.22 (1.2)	6.87 (1.4)	5.28 (1.0)	0.136
Total extractable N (ppm)	8.41 (2.0)	8.10 (1.7)	14.65 (3.0)	14.34 (2.9)	0.070
Nitrogen mineralization	0.90 (0.2)	0.97 (0.2)	1.55 (0.3)	1.07 (0.2)	0.215
Nitrification	-1.05 (0.2)	-1.07 (0.2)	-1.94 (0.4)	-1.38 (0.3)	0.097
Soil respiration	1.34 (1.0)	0.88 (1.0)	1.26 (1.3)	0.31 (0.2)	0.044

Numbers in parentheses indicate standard error

Experimentally restored plots had:

- NH4 and Extractable nitrogen similar to native plots
- Higher rates of nitrogen immobilization.
- Potential soil respiration similar to invaded plots

Overall Conclusions

- Chaparral vegetation is resistant to invasion as long as a high canopy cover is maintained.
- Chaparral soil structure and function is altered by exotic plant invasion and thus not resistant to the impacts of invasion.
- The presence of exotic annuals slows the rate of recovery of both native vegetation and soil characteristics following fire indicating that exotic plant presence alters post succession success.
- Removal of exotic plant species can facilitate recovery of extractable soil nitrogen availability which indicated these soils have potential for resilience but not all chemical soils pools are as resilient.
- Longer duration studies are necessary to fully understand chaparral soil resilience to exotic plant invasion.

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